TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

ALBERT FINTA

IMPROVIG COSTING METHODS OF AN SME INDUSTRIAL MANUFACTURING COMPANY

Master of Science thesis

Examiner: prof. Petri Suomala
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ABSTRACT

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Knowing the costs in a manufacturing company is essential for profitable business. Accurately identifying costs on product level helps managers to do decisions on product portfolio, and for this case also make decisions on manufacturing location of a specific product.

The main research question was to develop a costing system for an SME manufacturing company. This study took a realistic approach, as the goal was actually to implement the costing system. The whole process started with a study of available costing systems. An activity-based standard costing framework was created, which adds variance analysis from standard costing to the best practices of activity-based costing. The intervention part of the study was to implement the costing system in the actual production environment. The study describes in detail the steps of implementing the costing system and especially the practical challenges that are present in real-life companies.

As result of the study, the first preliminary product costs were calculated automatically mainly using the information available in the ERP. After analyzing the calculated costs, it was concluded that the first results were not very reliable. The costing system did not reach a maturity level high enough to provide reliable cost information for decision-making. An important question regarding the validity of cost information is that how the information will be utilized. In this case, where one goal is to compare costs between locations i.e. factories, it is also important that costs are calculated with same principles. Thus, the absolute accuracy of information is not the only goal.

TIIVISTELMÄ

ALBERT FINTA: Kustannuslaskennan kehittäminen valmistavassa PK-teollisuusyrityksessä
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Kustannusten tunteminen valmistavan teollisuuden yrityksessä on ensiarvoisen tärkeää kannattavalle liiketoiminnalle. Kustannusten tunnistaminen tuotetasolla auttaa avainhenkilöitä tuoteportfolioon liittyvässä päätöksenteossa, ja tämän tutkimuksen tapauksessa myös tuotteen valmistuspaikkaan liittyvässä päätöksenteossa.

Tärkein tutkimusongelma oli kustannuslaskentajärjestelmän kehittäminen valmistavalle PK-teollisuusyritykselle. Tutkimuksessa oli realistinen ote, sillä tavoite oli myös käytännössä toteuttaa kustannuslaskentajärjestelmän implementointi. Työn alussa tutkittiin mahdollisia kustannuslaskennan menetelmiä. Työn tuloksena syntyi toimintoperusteisen standardikustannuslaskennan viitekehys, joka yhdistää standardikustannuslaskennan standardieroanalyysin toimintoperusteisen kustannuslaskennan parhaisiin puoliin. Työn interventionistinen osuus oli kustannuslaskentajärjestelmän toteuttaminen käytännössä yrityksen tuotantoympäristössä. Toteuttamisen käytännön vaiheet ja erityisesti käytännön haasteet todellisessa ympäristössä on kuvattu seikkaperäisesti.

Työn tuloksena ensimmäiset alustavat tuotekustannukset laskettiin automaattisesti pääasiassa perustuen toiminnanohjausjärjestelmästä saataviin tietoihin. Kustannusten analysointi kuitenkin osoitti, että ensimmäiset tulokset eivät olleet kovin luotettavia. Kustannuslaskentajärjestelmä ei saavuttanut riittävää kypsyyttä, jotta sen tuottamaa kustannusinformaatiota olisi voinut käyttää päätöksenteon tukena. Tärkeä kysymys tiedon oikeellisuuteen liittyen on, mihin tietoa halutaan käyttää? Tässä tapauksessa yksi tavoite oli verrata kustannuksia eri tuotantolaitosten välillä, jolloin on tärkeää myös se, että kustannukset on laskettu noudattaen samoja periaatteita. Tässä tapauksessa kustannusinformaation absoluuttinen tarkkuus ei ole ainoa tavoite.

PREFACE

Writing this thesis in Hungary has been an unforgettable experience and I would like to especially thank my manager at that time Juha for arranging this great opportunity to work one year as an expatriate in Hungary. The year has taught me a lot, both professionally and personally. I would like to thank professor Petri Suomala for the comment that helped me steer the study to correct direction. I would also like to thank all of my colleagues in Hungary and in Finland for the support and the comments regarding the study. And finally, a warm thank for my fiancé Riina for understanding and supporting me in this long process.

Tampere, May 23rd 2017

Albert Finta

CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

ABC	Activity Based Costing
BOM	Bill of Material
CSV	Comma-Separated Values
ERP	Enterprise Resource Planning
FJV	Foreign Joint Venture
KPI	Key Performance Indicator
MOQ	Minimum Order Quantity
SME	Small and medium-sized enterprises

1. INTRODUCTION

1.1 Motivation for product costing and objective of the study

Product costing serves an important role in the processes of a company. It forms a basis for pricing (Alnestig & Segerstedt 1996, pp. 455–456) and it is used in decision making in different cases. Example uses are deciding about new products and targeting cost saving actions correctly (Innes & Mitchell 1995, pp. 139–145). It is also used in valuating inventories (Alnestig & Segerstedt 1996, p. 455; Innes & Mitchell 1995, pp. 139–145). An even more refined costing system is needed e.g. when increasing the number of products produced or when different operations are performed on different products i.e. the cost structure of products are different.

It has been shown that companies utilizing more accurate costing systems are more profitable and have lower administrative expenses (Pizzini 2006, p. 203). This gives a motivation to develop the costing system to a more refined direction to provide more accurate and detailed cost information for managers.

Of course, generally for companies the main objective is to increase profitability, and one way to do it is to minimize the costs. However, the costs of unit-level operations most likely have been trimmed very close to optimal performance (Cooper & Kaplan 1991, pp. 132–133), so the savings should be targeted from a higher level, such as batch-level costs and facility sustaining costs. Without detailed analysis, these costs cannot be assigned to a single item, and thus it is likely that they have been imperceptible to management. This leads the focus of the study towards higher level operations.

The main motivation for product costing regarding this case is to obtain the profitabilities of different products and the possibility to aggregate the information on customer level, i.e. to obtain the profitability of customers. The goal is that the costs are comparable between Teknikum and the Foreign Joint Venture (in the future abbreviated FJV), so that product transfer decisions can be made based on the cost information. If costing principles would differ, the cost information could be distorted and it could affect the decision-making of which products to transfer, or for new product in which factory to manufacture. Another perhaps more typical use for product cost information is to make decisions of product and customer mix. In case of the FJV these are significant questions, as the largest customer is responsible for about half of the company's revenue.

In case of product transfers, it is important to select wisely which products to transfer. That is because different products have different labor, machine and material ratios (The

ratio is calculated by dividing the cost in question by sales price). From the transfers' point of view, the labor ratio is the most interesting. Machine costs are roughly on the same level in Finland and Hungary, since comparable sized machines are similar by specification, cost of electricity is on the same magnitude and also service costs are on the same magnitude. Material costs are almost identical, although minimal savings for Hungary's favor are possible due to shorter distances to suppliers in Europe and thus smaller transport costs. However, the labor cost for rubber/plastic machine operator in Hungary is roughly $1/5^{th}$ of the cost in Finland. Thus, the largest saving potential is in the products that have the highest labor ratio. Managers should focus on evaluating the transfer possibilities of products that have a high material ratio. For these decisions, it is important that the costs are calculated according to same principles in Hungary as in Finland.

Although labor ratio and thus labor cost is the main driver for product transfer for a given product, it must be noted that the big picture has a lot more variables. First, sometimes the lead time requirements for local Finnish customers are so tight that transporting the products from Hungary is not possible fast enough. Second, the customer might deny the transfer for various reasons, such as quality concerns, reliability of delivery concerns or even in the fear of comprising commercial secrets e.g. leaking of mold designs or raw material recipes. The latter has been more prominent regarding transfers to East Asian countries, especially to China, but for a buyer that have had bad experiences in such situation it may be an important point of consideration. Third, in most of cases a single item is connected somehow to other items. For example, a product can have different variants, different sizes or it can be manufactured of different materials. Also, some products can share a very similar technique to manufacture. In these cases it might be feasible, or even mandatory, to manufacture these items in one location. Thus, the whole picture must be considered when evaluating products to be transferred. Finally, and probably most importantly, the consequences of end of production in Finland must be evaluated very closely. Theoretically direct labor could be laid off easily, but in reality there is a delay how fast employees can be laid off, it causes additional expenses, subsequent lay-offs can deteriorate the team spirit at the workplace and also the reputation of the company as a reliable and fair employer can be damaged. The indirect costs are even more challenging, as they include machinery, buildings and personnel of supporting functions. If indirect costs cannot be decreased, the indirect cost allocation of production leaving in Finland will increase. To answer these questions, accurate costing information is needed.

1.2 Requirements and expectations for the costing system

As Geiger (1999, p. 47) points out, the costing system should be designed so that it serves the management's needs, that is it, provides useful information for decision-making purposes. The costing system is not intended to support external reporting, where different information is aggregated often to company level. Rather, management is interested in more detailed department level or even product level information. It is also important to

consider how much it costs to build and sustain a costing system. An overly complicated costing system might not provide more valuable information than what it costs to implement and operate the system.

Pizzini (2006, p. 180) indicates that the more functional costing systems can provide more detailed information, classify costs more accurately according to their nature, report cost information frequently enough and calculate variances of costs. These can be seen as requirements for a costing system.

During the first discussions with the FJV's management emerged that in an ideal case all the cost information would be available directly from the ERP. This probably was a bit contradictory to Teknikum's requirement, as Teknikum would like to consolidate the information to its systems. Another interesting expectation of costing was from the main accountant that according to her, the only proper and fair way to assign fixed costs is allocation by revenue. Clearly, she was rather unaware of the possibilities of Activity Based Costing, as most costs are not related to the sales price of a product and thus revenue.

1.3 Teknikum Group Ltd. and the FJV

Teknikum Group Ltd. is one of the leading industrial polymer technology groups in the Nordic countries. Teknikum has a revenue near 50 million EUR and around 380 employees. Teknikum has three factories in Finland, one in China and sales offices in Germany and Russia. Teknikum manufactures customer specific polymer products, industrial hoses & coupling and wear, tear & corrosion protections such as rubber linings. Teknikum has a minority ownership of the FJV's shares. Teknikum is not among the biggest player globally in polymer manufacturing companies. The larger players can utilize the economies of scale and achieve lower unit costs for large manufacturing batches. Thus, it is evident that Teknikum's competitive advantage has to be something else than achieving the lowest possible unit costs. Teknikum has a deep knowledge of materials, mold design and manufacturing methods. With this knowledge Teknikum can co-operate with the customer to find together the best possible solution for the customer's needs, rather than just manufacturing a batch according to an order. Teknikum's small size allows flexible and agile operations, such as manufacturing a small batch with a very short lead time. Despite Teknikum's focus not being cost leadership, the costs still play a significant role. Customers are more and more cost aware, and due to globalization finding new suppliers globally is easy. To maintain the competitive edge, prices must be kept reasonable, and to do so without scarifying profitability, the cost need to be kept down. One interesting application for the cost information is studying the old products that have been manufactured for a long time. Both Teknikum and the FJV have products that have been manufactured for many years, in some cases for over ten years. Both companies have evolved during the years, direct costs have changed and especially indirect costs have changed due to

changes in company structures and sizes. As accurate cost information has not been available, changes in pricing have been done utilizing the available information: perhaps reflecting the raw material price changes or market prices in the competitive situation. Since Teknikum has already implemented more accurate product costing, situations have emerged where the actual costs of old products have differed significantly from what they were believed to be.

The FJV is a Hungarian manufacturing company manufacturing molded plastic and rubber parts, die-cut foam parts, and upholstery foam parts as well as laser & water jet cut parts and injection molding tools. The FJV has a revenue about 20 million EUR and around 320 employees.

Teknikum has a deeper knowledge about product costing and standard costing as Teknikum's Financial Director has a background from the electronics industry, from a company where product costing was utilized in a highly sophisticated manner. So far this knowledge has been transferred to Teknikum's operations in Finland. The FJV set up its ERP just five years ago, and the system has been expanded during the years. Thus, it is understandable that precise product costing is not yet implemented, especially without knowledge and practical experience of costing systems. The main focus of ERP development has been on manufacturing, warehousing and other daily operations rather than management accounting.

2. THEORETICAL BACKGROUND

2.1 Literature review of needs for costing

First, it is important to understand the fundamental reasons for cost management. Managing costs without a fundamental reason would have no benefit for the company. Chapman and Kern note in their study that an ABC costing system has an effect on profitability of the company if the costing system helps the organization in making operational decisions (Chapman & Kern 2012, p. 26). Thus the fundamental reason of costing system is to help making operational decisions. This is a quite high level and general statement, but in can be deconstructed to smaller more specific questions. A comprehensive study by Boyd and Cox shows that the five most important questions where cost accounting information have been utilized by companies in decision making are 1) product pricing, 2) offer or discontinue products, 3) make or buy decisions, 4) and plant expansion or contraction and 5) equipment purchases (Boyd & Cox 2002, pp. 1882–1884). The study confirms that these are actually the decision points that are also mentioned elsewhere in literature, e.g. Hansen et al. 2007, pp. 4–9; Drury 2012, pp. 194–195; Atrill & McLaney 2009, p. 23. Cost information is also important for product designers, as they can make design decision based on the total costs of a design option (Tornberg et al. 2002). King et al. (1994) categorize in their literature study the applications for ABC as following: budgeting, cost analysis & reduction, performance measurement, new product design and customer profitability. These applications however are not on the same level, as customer profitability analysis essentially relies on measuring performance and analyzing costs. There are also even more specific needs for accurate costing, e.g. setting transfer prices between organizational units of a consolidated company to ensure correct and fair distribution of profits along the production chain of a product (Otley 2001a).

2.2 Costing systems

A literature study by Pizzini (2006, p. 180) shows that the most common ways to classify costs are classification by fixed/variable, direct/indirect and controllable/non-controllable costs. Drury (2012, p. 24) presents additional aspects, such as period/product, relevant/irrelevant, avoidable/unavoidable, sunk, opportunity and incremental/marginal costs. Horngren et al. (2015, p. 36) present fixed/variable and direct/indirect costs as main classification. Direct costs are such costs that can be assigned directly to one product. For example, material cost is a direct cost, since it is directly consumed to manufacture a named product. Direct labor, such as assembly of a product, is also a direct cost since it belongs directly to a specific product. Assigning direct costs to a cost object, such as an item, is called cost tracing. On the other hand, administrative costs, salaries of management and rent of production facilities are indirect, since they affect also other products.

The process of assigning these indirect costs to a cost object is called cost allocation. (Horngren et al. 2015, p. 107). Variable costs are costs that vary in proportion of manufacturing volume variation. Such costs are for example direct labor and material. Fixed costs are costs that are independent of manufacturing volume. Such costs are for example management costs and shift supervisor's costs. Classifying costs by fixed/variable is not always that easy, since most "fixed" costs are fixed only up to some extent. For example, salaries of a purchasing department are fixed, but if operations volume increase enough, more purchaser need to be hired. Thus, fixed costs are only fixed on a defined timespan. Direct labor, which is usually presented as variable cost in direct costing (Boyd & Cox 2002, p. 1881), is actually semi-fixed or step-fixed, as there is a delay of laying off and recruiting, and it usually must be done at least on a whole person level. Thus, on a short period it is not directly proportional to operations volume (Drury 2012, p. 30). There are also semi-variable or mixed costs, such as maintenance costs, which has a variable part (related to wear of machines) and a fixed part (planned annual maintenance that need to be done irrespective of operations volume) (Drury 2012, pp. 30–31; p. 184). These aspects make the classification of costs by their behavior challenging.

On highest level Drury (2012, p. 46) classifies costing systems as either direct costing systems, which include only direct costs, and as absorption costing systems, which also include indirect costs. He further divides absorption costing methods to traditional costing systems and Activity Based Costing. Horngren et al. divide traditional costing methods to job costing and process costing. In job costing, the cost unit is a distinctive product or service, which consumes resources in a different way than other cost units. Job costing is useful for rather large or distinctive projects and products. In process costing the cost object is a series of mass production units. The distinctive units of a mass production series are identical to each other, and it is logical to treat the series as a whole. A single unit has the average cost of the production run. However, it must be noted that a product can be manufactured in different batch sizes and by different machines. Every combination of batch size and machine, and possible other variables, must be treated as a distinctive process that is costed separately. (Horngren et al. 2015, pp. 108–109). In a modern manufacturing environment, where number of possible combinations of machines and batch sizes is high, the feasibility of process costing is decreased, as it would be costly to keep the distinctive processes up to date.

In Activity Based Costing, direct costs, such as material, direct labor and machine cost, are still traced directly to products, but overheads are allocated to cost pools rather than directly to products by an overhead rate. Designing an ABC system consists of four phases: First, the most important activities are identified. Such tasks are for example different assembly operations, machine set-up and warehousing. Second, costs are assigned for each activity. The costs caused by an activity within a set time period are pooled together. This gives the information that for example how much the purchasing function costs for the whole company in one month. Third, an appropriate cost driver is selected

for every activity. The cost driver determines how the costs of an activity are assigned to cost objects. Finally, the costs of the activities are assigned to products based on how much of an activity each product needs. (Drury 2012, pp. 258–259). For a more detailed view on setting up an ABC system, see for example Drury (2012, pp. 258–259) and Horngren et al. (2015, pp. 158–160).

In Activity Based Costing it is important to identify different hierarchical levels of costs. Cooper and Kaplan (1991, p. 132), Drury (2012, p. 259) and Horngren et al. (2015, pp. 161–162) present it as a four-level hierarchy. The first level is the Unit level activities. Unit-level activities are activities that are performed on every unit produced. That is, the number of activities is directly proportional to number of items manufactured. For example, automated molding of plastic is a unit-level operation. Also, direct labor and direct material are unit level costs. Batch-level operations are performed each time a production batch is made. Producing more or less units in same batch does not affect the batch-level operations. For units made in a single batch the batch-level costs are fixed. An example of batch-level operation is set-up of production machines. Product-sustaining activities are activities that do not depend on production volume or number of production batches. Examples of product-sustaining activities are product designing, product development and technical support for a product. The last hierarchical cost level is Facility sustaining activities. These are activities that support the whole business and are (up to a certain limit) not related to number of different products, production batches or production volumes. Examples of facility sustaining costs are top management salaries, facility rents and cleaning costs. Only significant changes in operation volumes, such as factory expansion, would change these costs. Kaplan and Cooper (1998, pp. 89–91) also mention an additional hierarchical level in addition to these four levels commonly presented in literature. Customer-sustaining activities are activities that are performed regardless of number of products, batches or production volumes, but they are performed for every customer. Keeping customer relations or technical support are examples of customer-sustaining activities. (Kaplan & Cooper 1998, pp. 89–91). Also, if a customer has some special requirements for example related to order handling or data exchange these could be classified as customer-sustaining activities.

An essential reason for an accurate costing system is to avoid overcosting and undercosting. Overcosting occurs, when more costs are assigned to a cost abject than it causes in reality. Undercosting, on the other hand, occurs when less costs are assigned to a cost object than it causes in reality. (Horngren et al. 2015, pp. 151–152). Over- and undercosting can result from different reasons. Typically it happens when costs are assigned to a product based on different allocation base than the cost is caused in reality. For example, cost of purchasing function may be allocated to products by revenue, since it easy to implement, but it might lead to biased costing. Let’s take as an example products A and B with similar revenues. Product A is made of few raw materials that can be stocked for long time, so that minimal purchasing actions are required. On the other hand, product B

requires many different raw materials that need to be ordered separately for every batch. In this case, product B causes more purchasing costs. If purchasing costs are allocated by revenue, it leads to undercosting for product B and overcosting for product A. This creates a situation where products cross-subsidize each other (Horngren et al. 2015, p. 152).

2.3 Standard costing and variance analysis

In standard costing the activities performed on a cost object are standardized. For example, an assembly of a product, the direct material and direct labor consumptions are predetermined. (Hilton & Platt 2014, pp. 410–411). It can also contain fixed overheads (Drury 2012, p. 433). It makes standard costing suitable especially for manufacturing industry, where many common repetitive operations are performed on products. Even if a factory produces many different products and variations, standard costing can be suitable as long as it is possible to standardize the manufacturing phases. (Drury 2012, p. 424). By making these assumptions of standardized resource consumption utilizing the costing system is significantly easier, as every operation do not need to be measured. Actual measuring is done on a more aggregated level such as department or responsibility center level. (Drury 2012, p. 426)

Setting up and utilizing a standard costing system consists of three distinct phases (Hilton & Platt 2014, p. 412): First, standard costs are set by analyzing historical data to find out what it did cost, or taking an engineering approach to find out what it should cost, or a combined approach of analyzing historical data and the processes. Analyzing the historical data is fairly simple, whereas by engineering studies it requires careful studying of specifications, plans, equipment and actual operations. (Drury 2012, pp. 426–427). The historical data answers to question “What it has cost?” and the engineering approach answers the question “What it should cost?”. The engineering approach has the advantage of trying to find the most efficient way, since it is not tied to old and possibly inefficient practices (Drury 2012, p. 427). Second, the actual resource consumption is measured on a level that it feasible to do. Third, the calculated and actual resource consumption is compared and the management analyzes the variance. (Hilton & Platt 2014, p. 412). Analyzing the variances is an important part of standard costing, since that makes it possible to see the problems and improve operations. Analyzing the variances and making corrections to standards based on significant changes should be a continuous process and it is a key part of standard costing (Drury 2012, p. 429).

To give meaningful information for managers the variances should be detailed enough. A common practice is to report separately material, direct labor and variable overhead variance. (Hilton & Platt 2014, p. 411). Another method to add the diversity of information is to divide further each component to two different components: price and amount. The price variance reflects the variances in purchasing prices and it is not de-

pendent on the manufacturing performance i.e. resource consumption. The amount variance on the other hand reflects the manufacturing performance, that how much of a resource is consumed. (Hilton & Platt 2014, p. 426)

Generally, for all different variances (labor, material and variable overheads) the following formula apply for usage i.e. performance variance

$$Usage\ variance = (std\ quantity - actual\ quantity) \times std\ price, \quad (1)$$

and for price variance respectively

$$Price\ variance = (std\ price - actual\ price) \times quantity\ purchased \quad (2)$$

(Drury 2012, pp. 433–434). For a detailed presentation and formulas for calculating different variances see Hilton & Platt 2014, pp. 417–422; Drury 2012, pp. 431–439 or Horngren et al. 2009, pp. 258–260.

Despite the importance and possibilities of variance analysis, it is not directly shown that the extent of costing system's ability to calculate variances has impact on a company's profitability. It may also be that the not so profitable companies spend more effort on variance analysis, to be more profitable in the future. (Pizzini 2006, p. 203). Nevertheless, variance analysis is a core part of standard costing, and essentially it is the only way to get feedback of the costing system.

Drury (2012, p. 72) defines machine hour rate as an hourly rate that is calculated by dividing the cost center's overheads by the number of machine hours. Horngren et al. (2009, p. 108) illustrate machine hour rate as indirect costs of a machine divided by hours the machine has run. However, Drury and Horngren et al. do not specify what to include in indirect costs of a machine. Drury's definition assumes that the cost center only has the machines and directly machines-related functions. If the cost center had also other costs than machine-related costs, the machine hour rate would include these costs and it would not be a true machine hour rate. Thus, it implies that cost centers are set up as required for activity based costing.

2.4 Sources of error

Datar and Gupta (1994, pp. 568–569) classify the errors in product cost estimates to three different classes. Specification error occurs in a situation where the cause of the costs does not match the selected cost driver. For example, allocating set-up costs based on production volume would cause a specification error, as set-up costs do not vary relative to production volume, rather to number of set-ups. Aggregation error occurs when activities with different costs are pooled to a single activity, thus creating a heterogeneous cost pool. Measurement error occurs due to insufficient measurement methods, guidelines or techniques. For example, total set-up cost contains labor cost of different staff members,

energy and possibly wasted material or other consumables. As set-up cost consists of different costs needed to be measured separately and each of them contain measurement error, the total set-up cost is more prone to measurement error compared to a simpler activity such as manufacturing with a single operator. (Datar & Gupta 1994, pp. 568–569)

The textbooks of cost management by Drury (2012), Hilton & Platt (2014) and Horngren et al. (2009) do not discuss the possible sources of costing errors very broadly. They do not classify the sources of error and only discuss errors what are classified here as specification based errors. Horngren et al. also touch on the aggregation based error by mentioning that broad averages lead to distorted costs (2009, p. 157), although all three emphasize the importance of homogenous cost pools for accurate costing.

2.5 Refining costing systems

Horngren et al. suggest three main guidelines for refining a costing system:

1. Use direct-cost tracing when economically feasible. Using direct-cost tracing eliminates the unnecessary need of cost allocation and thus increases the accuracy of costing.
2. Make indirect-cost pools more homogenous by increasing their number. To follow the cause-effect-relationship more closely, the cost items in the cost pool should have similar cost drivers and thus make the cost pool homogenous.
3. Use the cost driver as an allocation base for the cost pool. This is possible with homogenous cost pools. (Horngren et al. 2015, pp. 157–158)

Park and Simpson (2008, p. 105) have similar recommendations regarding direct-cost tracing and homogenous cost pools. In addition, they suggest using different kind of activity cost drivers based on what way an activity is consumed. They present three options for types of activity cost drivers: Transaction cost driver, duration cost driver and intensity cost driver. Transaction cost driver measures the number of resource usages for and activity. It is the simplest i.e. least expensive method, while also least accurate. Intensity cost drive measures how much resource is consumed during an activity. It is the most accurate, but also the most complex i.e. expensive to implement. Duration cost driver measures the time required for an activity and in terms of accuracy and cost it stands between the latter two. (Park & Simpson 2008, p. 106). However, increasing the complexity of costing system by increasing the number of cost pools and using more complex cost drivers can increase the total number of measurement errors (Datar & Gupta 1994, p. 582).

Despite Park and Simpson (2008, p. 106) claim intensity cost driver as the most accurate cost driver, it is also the most prone to measurement error. This is because resource con-

sumption per activity performed may be difficult to measure, compared to duration (simple) or number (very simple). However, they describe the intensity cost driver as the most expensive to implement, indicating their understanding of accuracy requirement. Still it is important to understand that unless properly implemented an intensity cost driver can easily become very inaccurate.

Datar and Gupta suggest that the focus of refining cost pools should be on the cost pools that have the largest potential for error instead of focusing on the largest cost pools. Especially care should be taken with general and administrative costs, as allocating those costs accurately to specific products is a challenging task and thus refinements related to these cost pools might not imply more accurate costing. (Datar & Gupta 1994)

2.6 Activity-based standard costing framework

The studied literature does not mention using together activity-based costing and standard costing. The two costing methods are not mutually exclusive, as activity-based costing has a larger emphasis on planning and setting up the activities, whereas the emphasis of standard costing is on the variance analysis. Variance analysis is performed after the costs have been accumulated and actual costs are available. Despite standard costing contains activities and costs are determined for these activities by different methods, seems that no link to activities of activity-based costing have been identified in literature. Standard costing provides valuable information in terms of variance analysis, but it is something that is not available to managers only by means of activity based costing. On the other hand, activity based costing enables to define cost drivers to match the real-world situation as closely as possible.

To combine the best practices of standard costing and activity based costing, a framework of activity-based standard costing is created. In ABC standard costing, the process of creating a standard costing system is followed, as described in chapter 2.2. In the end, standard costs for these activities are set according to methods of standard setting, described in chapter 2.3. After actual cost information is available, a variance analysis is performed where the planned costs (i.e. standard costs) are compared to actual costs. This gives manager significantly more information compared to a plain ABC system, without adding significant complexity to the system.

3. RESEARCH METHODOLOGY AND MATERIAL

3.1 Research methods

The study was conducted as an interventionist study. The whole process described here is presented visually in Figure 1. This chapter follows the chronological order of the study, although in reality the steps overlapped significantly. First, the current state had be studied to understand the situation deeply. This was accomplished mainly by doing interviews with accountants, work supervisors and management, as well as observing and interviewing the purchasing, logistics and sales functions. Part of the background study was to familiarize with the accounting and ERP system. A literature review was made to study the available costing methods and theories related to them. Also to further support and complement the motivation behind making this study of product costing, a literature review of the main motivations behind cost management was conducted.

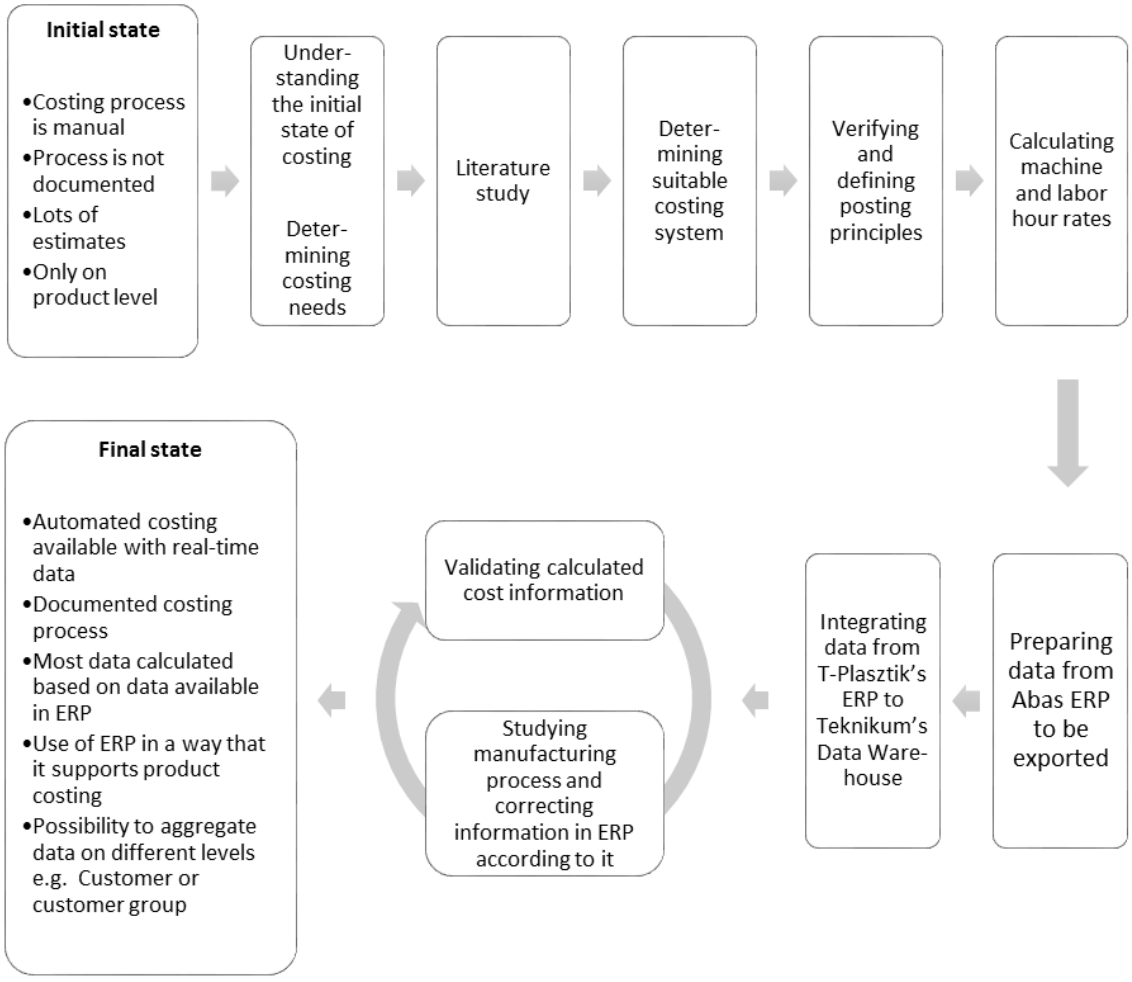

Figure 1: Research process

As proper cost posting to accounts is the basis of costing, the first thing to do was to ensure that costs are classified correctly and posted to proper accounts. To do this, accounts were reviewed and the content (i.e. the invoices posted to an account) of every account was checked briefly. The goal was not to audit the work of the financial department, rather to ensure that general principles are correct. The next task was to form a Chart of Accounts so that the accounts can be grouped the same way that Teknikum's account. The Hungarian accounting practices have some minor differences compared to Finnish practices, making a simple one-to-one mapping impossible.

The variable cost of a product consists of labor cost, machine cost and material cost. These costs had to be checked or determined. Material costs were mostly correct, as the information was actually stored in ERP and utilized actively. Machine and labor hour rates on the other hand were not stored in ERP or calculated automatically by the system. Determining the rates had to be done manually in Excel. The process was quite time-consuming, as new aspects arose as the whole picture was getting more clear. The timespan of this phase was roughly half of the study i.e. 6 months, as calculations were refined and corrected as better information was available. As no single person had a such clear view, the information had to be gathered from different persons. Also, at the beginning it was unclear what exact questions to ask to get right information. An example of a problematic question was to what extent to include maintenance costs in machine costs and how to identify these maintenance costs from other maintenance costs.

Since standard costing relies on the BOM that is stored in ERP, the next task to do was to verity that the BOMs of manufactured products are correct and the prices, units, unit conversions etc. are correctly set. This was actually a very time consuming process, since thousands of products exist in ERP. Due to vast amount of data, it was not possible to verify all items. Rather the efforts were concentrated on most significant items measured by revenue. As in many situations, the 80/20 rule applies also here; rather small number of items account for majority of revenue. Thus, by verifying the most significant ones was a good enough practice. Later when first estimates of product costs were available, the efforts could be focused on the largest deviations, such as surreally high or low sales margins (thousands of % negative or positive) and on particular sales margins, such as 0% which would indicate (usually for a transfer product) that the purchase price and sales price are equal or, 100% which would indicate that the BOM contains no variable costs at all. Verifying BOM structures was performed in co-operation with the manufacturing management, since they had a deep knowledge about the actual process of manufacturing. Despite focusing efforts on obvious errors and largest deviations, it is more than likely that errors remain in the data. It is also possible, that two different kind of errors counteract each other leaving the result within plausible limits, although the result provides no actual valuable information, as it is based on false information. To minimize the possibility of this kind of invisible errors, the costs were analyzed as separately as possible. That

is, the labor cost, machine cost and material cost were investigated separately, and for this data all the method described earlier in this chapter were utilized to spot errors.

The aim for Teknikum's management was to have the costing information of the FJV in same system as Teknikum's. To accomplish this, the information from the FJV's ERP had to be exported to Teknikum's analytics platform. The information needs were discussed with Teknikum's Business Control and the implementation of the export was made by the FJV's IT-department. The export process found out to be rather tricky, as with current software licenses no proper database access was available for the FJV 's ERP. The only way to export data was to create a semi-automated system, where views, searches and queries created in ERP could be saved directly to CSV text file.

After successful data import to analytics platform first, efforts to add standard variance for production departments could be made. This revealed significant anomalies in product costs and required further corrections in product BOM's. Costs verification and correction was a continuous improvement process. This process could be started during fall and was continued until the end of the year. The data set was extended when new whole months were available.

In addition to constantly communicating with Teknikum's Business Control, the Business Controller visited the FJV once during the summer to support the process even better. Also, an important part of the intervention was to create an instruction of BOM practices. This document was part of the intervention, but also a result of the whole study. It is discussed more in detail in chapter 5.1. An important part of the process was the continuous discussion with especially the FJV 's manufacturing management, that whether or not the calculated costs are realistic. Of course, the goal of the study was that costing would not be based on guessing and feelings, but it was an important part to listen the opinions of manufacturing management. In case that the feeling differed significantly from the calculated value, it was discussed more in detail and the grounds of the calculation was explained to manufacturing management. For example, in one case the manufacturing management claimed that the cost of a certain product cannot be as high as it seems by the calculation. After looking the details, all the elements seemed right, but the batch size was significantly smaller than what was expected and planned. The small batch size caused the high unit prices. After seeing the facts, a consensus was reached that the calculation seems right and the cost is indeed higher than expected.

4. QUALITATIVE ANALYSIS AND FINDINGS IN THE CASE COMPANY

4.1 Qualitative analysis of cost information

In addition to generating more accurate product costs to support decisions relating a single product or product family, there are also other indirect benefits of Activity Based Costing. The benefits of implementing a more accurate costing system, and especially Activity Based Costing is not just knowing the costs, but rather the changes in way of managing overhead costs. The ABC system help managers to see overhead costs in a different way and thus improve the business processes to get the actual benefits in terms of costs savings. (Otley 2001b, p. 249). Of course, knowing the product costs and profitability accurately also help managers in making product mix decisions, as this was one of the main motivations for this study, but as Otley points out it is not the most significant factor for the whole business.

However, the significance of product cost information in decision making is not totally unambiguous. In their study Brierley et al. note that the importance and extent of using product cost information varies between companies and more study would be needed to understand the reasons why some companies decide to utilize product costing and others do not. On the other hand, among studied companies product costs were well utilized for price setting. (Brierley et al. 2001, pp. 231–233).

As accounting information is generally categorized to financial accounting and management accounting, product cost information is part of management accounting (Drury 2012, pp. 5–6). Drury specifies different users for accounting information, but according to him product cost information is mainly utilized by managers, although Drury does not specify what level of management this concerns. Webster and Hoque conclude in their study that the main users of cost information are higher executives and managers of an organization (Webster & Hoque 2005). They also mention that cost information can be provided to governmental funding authorities (Webster & Hoque 2005, p. 49), but this cannot be generalized to all companies as the case study based on a hospital, which funding and control differs significantly from a privately-owned company. Thus, providing cost information for governmental authorities would not concern privately owned companies, unless they receive such funding e.g. in form of subsidies.

Different levels of managers can utilize the cost information across an organization. They also have different needs, for example the senior management can utilize best the information in financial terms (Otley 2001a) rather than in other terms, which are on the other hand very useful for operations planning.

4.2 Current costing methods

Currently the company uses a traditional costing method that is basically a process costing method based on actual costing. See for example Horngren et al. (2015, p. 664). Since production at the FJV is essentially mass production, costs are measured on a batch or shift level and can be divided back to one product. One main challenge regarding the costing is the inaccurate posting of costs. Some production-related costs are on general cost center, from where they can't be allocated accurately and by obeying the cause-effect-relationship. Another significant limitation is that all fixed costs are treated equally and they are allocated to products by revenue. Only such overheads that cannot be allocated by a cause-and-effect principle should be assigned by an arbitrary allocation base such as manufacturing cost. These overheads are essentially non-manufacturing overheads. (Drury 2012, p. 63)

The costing as a part of offering new products resembles standard costing as the offer is calculated based on given standard machine & labor costs and estimation of batch sizes and cycle times. However, the process does not contain any variance analysis, and the costs are not validated systematically. An actual costing can be performed afterwards, but the calculation still includes the estimates of machine cost and set-up cost. Thus, it is not a true actual cost.

The starting point was that a systematic tool for did not exist. Costing was performed in the quoting phase of new products and at the end of a financial year. All costing was performed in Excel with lots of external data that was not explicitly defined. Thus, for this study the existing spreadsheets were not very useful.

The FJV produces rather large variety of different products. Table 1 shows the main product categories with their batch sizes and unit costs. As we see, variation in batch sizes and unit prices exist not only between product categories, but also within a category.

Table 1: Main product categories with their batch sizes and unit costs

Product category	Batch size	Unit cost range
Injection-molded plastic parts	1,000's to 100,000's	0.001's to 1's of EUR
Injection-molded rubber parts	1,000's to 100,000's	0.01's to 1's of EUR
Manually assembled products	10's to 1,000's	0.1's to 1's of EUR
Rubber mixtures	100's of kg	1's of EUR/kg
Laser/water jet cut parts	1's to 1,000's	0.1's to 10's of EUR
Injection molding tools	1's	1,000's to 10,000's of EUR
Die-cut foam products	100's to 10,000's	0.1's to 10's of EUR
Manually sawn foam products	1's to 100's	0.01's to 10's of EUR

Injection molded plastic parts and injection molded rubber parts are the main scope of this study. However, since manually assembled products belong to plastic's cost center and rubber mixtures belong to rubber's cost center, they are included to some extent. The reason for costing rubber items is that Teknikum's main product is rubber and this gives valuable information for product transfer decisions. Including also plastics gives significant value for the FJV as injection molded plastic parts represents roughly 50% of revenue.

4.3 Evaluating different costing methods for the case company

As Teknikum is using a standard costing system, it is a good starting point for the evaluation. Fleischman and Tyson (1998) claim in their study that standard costing has not provided enough information for strategic decision-making and has also failed in cost reduction goals. This is a valid concern, as one of the most important applications of cost information is to assist in decision-making. Also Monden and Lee (1993, p. 26) claim that standard costing does not target aggressive cost reductions. Despite the evident critique, Attiea et al. (2010) find that standard costing is still a valid tool and is widely used across the industry. They assume companies could still favor standard costing due to its simplicity and flexibility and also find possible that companies develop more robust costing systems based on multiple methods. In addition to support by Attiea et al. standard costing has been utilized successfully at Teknikum to provide information for decision-making. This a rather strong argument for standard costing, as it proves that the organization (at Teknikum) has the required knowledge and the method is suitable for the industry. Without this background information, the choices in this study might have been different.

Based on the diversity of product mix and their very different nature (see Table 1), it is obvious that a traditional costing system cannot provide accurate enough cost information. Thus an activity based costing system is essentially required. As standard costing gives additional information by variance analysis, and more simplicity by allowing to substitute the actual costs with standard costs, it seems as a favorable solution for the case. Also, as getting comparable costs with Teknikum is one very fundamental goal of the study, choosing a standard costing system seems even better since Teknikum is using standard costing. Although it was suggested in literature to report separately the amount variance and price variance, it was decided to combine these to a single variance measured in EUR. An important argument for a combining the two components is that Teknikum's costing system currently does not support reporting price variance and amount variance separately. Taking into account the initial state of costing and the work required to get a working system it seems justified to rather take smaller steps a time.

4.4 Technical implementation of the costing system

For building the costing system and analyzing the cost data, there was basically three options: 1) internal costing functions of the Abas ERP system, 2) a separate Excel-based tool 3) an external analytics program. A total revamp of ERP system or even changing to another ERP system was out of question due to limited financial and time resources. After a quick study it seemed that the present version of Abas does not contain required tools for standard costing, although it might have been possible to acquire the missing functionalities. Implementing the costing in Abas would require very deep knowledge of the system. At the moment the best knowledge is in the FJV's IT-department. For the implementation of costing system enough support might have been available, but to further develop and sustain the costing system it might have been problematic, as costing system for the whole group is developed in Finland, but the implementation and knowledge of the system is in Hungary. For these reasons performing the costing in Abas did not seem favorable.

An Excel-based would have been easy to get started with, but only for a very limited amount of data. As the amount of data and complexity of the system increase, the limitations of a self-developed Excel tool might become a constraint. Also against this option was that neither the FJV nor Teknikum use such self-developed Excel tools, so no knowledge or support would have been available.

As Teknikum has just started using a new analytics tool Qlik Sense with promising results, it seemed the best option to use the same platform for the FJV's data. There was a couple of reasons for the decision: First, the data is handled the same way as at Teknikum, that is the basic data is kept up to date in ERP and the responsibility to do so is on the operative organization, e.g. the sales ensure that sales prices are correct, purchasing is responsible for purchase prices and production organization is responsible for accurate BOM's. The raw data is exported from the ERP and all re-structuring, grouping and the

actual calculation is performed in Qlik Sense. Second, the actual costing process in Qlik Sense was already implemented at Teknikum, so the task was essentially to integrate another data source to it. This made validating results significantly easier, as costs of similar products were already calculated with Qlik Sense. And finally, as the best knowledge of standard costing was in Finland, it was a natural choice to perform most of the calculation in Teknikum's systems.

With these considerations, the decision was to implement an activity based costing system based on standard costs in a such way that most of the information is obtained from the FJV's ERP system and exported to Teknikum's Qlik Sense analytics platform.

4.5 Cost centers

4.5.1 Current cost centers

Currently the FJV has the following cost centers:

- 01 Plastics
- 02 Rubber
- 98 Foam
- 06 Packaging material
- 07 Tooling
- 08 Maintenance
- 99 General (Administration)

Plastics cost center logically contains the plastics manufacturing department including quality and logistics personnel that only work in plastics department. Rubber cost center contains the rubber finished goods manufacturing department, but it also contains the rubber mixture plant, which produces rubber mixtures for internal use. Also this cost center contains the quality and logistics personnel the same way as Plastics.

The foam cost center contains actually three different manufacturing units: Technical foam, upholstery foam and laser & water jet cutting. Technically these three units are defined as sub cost centers of Foam cost center, but it has little use as costs can be posted to these cost centers, but reading the costs is only possible from Foam cost center i.e. the sum of all sub cost centers.

Tooling cost center contains the tool shop, which serves two different purposes: it performs tool maintenance and modifications internally, and tooling services for customers. Thus it serves as a support function for production cost centers, but it also serves as a production cost center by actually generating external revenue by selling tooling services.

As we see, besides General cost center, Maintenance and Packaging, only production units are defined as cost centers. Packaging is only used to separate the packaging material costs from the actual product costs i.e. it does not represent the packaging function, rather only the packaging material. The maintenance cost center contains the personnel and supplies of internal maintenance, so it is a fully functional cost center.

The general cost center plays a very significant role, i.e. it bears a large share of all costs. In addition to costs like administration, management, finance and ICT, it bears the costs of logistics, sales, quality and many production-related costs that could not be allocated directly to another cost center. The result of extensive use of General cost center is that accurate allocation of costs to departments, machines and products is difficult. Currently the costs are divided by a more or less fixed divider that is defined by the main accountant.

4.5.2 New cost centers

As a result of rather imprecise cost allocation, it was decided to create new cost centers to better support the principles of Activity Based Costing, especially for fixed costs. The new cost center hierarchy contains the following cost centers, with bolded cost centers being new additions to existing:

- 01 Plastics
- 02 Rubber
- 98 Foam
- 06 Packaging material
- 07 Tooling
- 08 Maintenance
- **Mixing plant**
- **Production general**
- **Purchasing**
- **Internal logistics and warehousing**
- **External logistics**
- **Sales**
- **Quality**
- 99 General (Administration)

A more detailed presentation with cost allocation methods and allocation bases is shown in Appendix A. Unfortunately, during this study it was now possible to actually implement the new cost center hierarchy.

To obey the matching principle, that costs should be matched to the activity that causes the cost as closely as possible, all activities that belong to only one cost center should be part of that cost center. The supporting cost centers should only be used if a cost cannot

be allocated to a production unit directly. One example is quality control during production. Rubber department has its own quality controllers and plastics department has its own quality controllers. In the first place, it might make sense to move these persons to the quality cost center, but then these costs should be allocated back to the manufacturing cost centers. Since one person works only in one department, it is best to have also the cost tied to that department. On the other hand, all other quality related costs that are not explicitly part of one single department should be in the quality cost center. The same applies to material handling workers, who work only in one department: the must be in the producing unit's cost center instead of internal logistics cost center. The placement of these employees was already correct at the beginning of this study, and thus no changes are required.

The idea behind the new cost centers was to separate operations that have different cost drivers or monitoring them separately provide meaningful information for decision-making purposes. Separating the rubber mixing plant from the rubber cost center has the grounds for and against it. Although it serves only the rubber manufacturing plant internally, it has a dedicated plant manager. As rubber products can be manufactured from either self-manufactured rubber mixtures or readily made commercially available mixtures it brings managers to a make or buy decision. If the mixing plant was part of rubber department, it is possible that other rubber products would cross-subsidize the rubber mixtures. Production general should contain all the production related costs that cannot be assigned to a specific manufacturing department. Such costs include auxiliary substances, utilities, workwear etc. that are manufacturing related, but purchased and possibly distributed centrally. The allocation base would not change by separating production costs from administrative general cost center, thus it would not change the product costs, but it provides meaningful information as it enables to measure the administrative costs. Purchasing function is common for the company, and all the costs have been so far on general administrative cost center. The reason to separate it from the general administrative cost center is to enable monitoring the performance of purchasing function and allow using a more refined cost allocation base, although the initially allocation base is still revenue. Internal logistics and warehousing is a distinctive function, so it should be a separate cost center. The costs of warehousing correlate well with the amount of goods in warehouse. A good easily measurable estimate is the average stock value. As internal logistics and warehousing are operated by the same personnel, a common cost driver should be utilized. External logistics depend largely on the distances from suppliers and customers, whereas internal logistics costs are very consistent. Thus their cost drivers are very different. Also, as external logistics are organized both with own resources and also as an outsourced service, it is important have reliable cost information to make the decision. Operating and maintaining an own truck fleet creates many kinds of costs, so it is wise to consolidate them to a cost center. The cost of external logistics should be invoiced to customers or included in the product prices. This has been the practice already, but without confidence that the invoiced or included price covers all the costs. Costs of sales

department are probably not the easiest to allocate, and thus it is understandable to use revenue as an allocation base. However, some customers require significantly more efforts than others, so a revenue-based cost allocation is not the best option. One possibility would be to allocate at least part of the costs by number of customer visits or by an estimate of sales representatives' time usage. The quality department, excluding quality inspectors in production departments, do a lot of process engineering related work. The resource consumption varies between departments and products, so revenue is not the correct allocation base. Determining the resource consumption on product level is difficult, but possible allocation bases to departments are number of claims and number of new product ramp-ups, as the ramp-ups (including the preparing for a ramp-up) create a significant workload for the quality department.

4.6 Posting principles regarding fixed and variable costs

Currently, purchase invoices are allocated to cost pools i.e. cost centers, which are shown in chapter 4.5.1. In case that a purchase invoice cannot be allocated to a single cost pool, it is divided to multiple cost pools. This is the case for some raw materials and supplies that are used in multiple departments. Also general and administrative costs, such as electricity, gas and workwear are allocated to cost pools during the accounting process, each invoice one by one. Although time consuming, this practice is good as far as the division is accurate i.e. it is based on items on the invoice or the resource consumption is otherwise known. In this situation dividing the cost to cost centers gives a more accurate result than using cost assignment by cost pools. However, the situation is more difficult if the resource consumption is not known exactly. In that case using a fixed divider might cause a bias that is very difficult to trace back later. If it is not possible to determine an exact divider, it is better to use cost assigning though cost pools.

One major problem was the lack of internal invoicing at the FJV. Originally, in 2014 and before the work of support functions was not compensated in any way. The support functions sales margin and operating profit was highly negative. It was accepted, that since supporting functions do not generate revenue, their operating profit can be negative. Of course, on a company level the loss of supporting functions compensated the profit of manufacturing units, thus the profitability of the whole company is correct and comparable to other companies. However, manufacturing departments were not comparable to Teknikum's manufacturing departments, since the FJV's manufacturing departments did not have any administrative costs. During 2015 the management reporting was developed significantly and the costs of supporting functions were distributed to manufacturing units. However, this was only done manually for management reporting, but not in accounting. During 2016 a need to measure the tool shops profitability emerged. This was because one of the tool shop manager's bonus KPI's was the tool shops profitability. The tools shop has external sales, but it also does tool modifications and repairs internally. Since internal jobs are not invoiced, it highly distorts the profitability of tool shop. To

cope with the problem, the company decided to transfer labor costs from tool shop to production units based on fulfilled internal maintenance hours. In accounting this was performed simply adjusting the percent that a cost center bears of the total labor cost. The result is that from accounting it is not possible to see how much costs was transferred from one unit to another.

4.7 Machine hour rate

The machine hour rates for different machines play an important role in quoting new products to be manufactured. Interviews with different people from sales, production and IT told that those are given numbers. During the interviews emerged that that the main accountant has defined the hour rates. An interview with her revealed there is no formula or template for calculating the hour rates, rather they have been set based on long-term knowledge of the company and production. The pricing template that sales department use has three elements: 1. electricity cost 2. other machine cost 3. sales margin. To get the electricity cost, the power bill is divided by nominal electrical powers of the machines. The other machine cost includes the following costs: Machine and tool maintenance costs, spare parts and auxiliary production materials, hand tools, rents, other variable costs and fuels & lubricants. These are all variable costs. The third element of the pricing template is sales margin. It is an estimated number to cover fixed costs and reach a target profitability level. Since no proper template for costing was available, the calculation of machine hour rate had to be started from scratch.

During the study the basic procedure to determine the machine hour rate was to

1. identify all machine-related costs for Financial Year 2015
2. gather all fulfilled manufacturing hours during year 2015 on per-machine level
3. study the distribution of electricity usage between departments
4. gather and study the specifications of machines to determine how large share of total electricity usage a specific machine consumes

Later the timeframe was focused to be January 2016 – June 2016 for the following reasons:

- Changes in product mix between the two timeframes
- Significant customers have left and new customers have replaced them between the timeframes
- Internal maintenance is allocated to production departments based on maintenance hours starting from January 2016
- More frequent physical inventories in 2016

Thus, the new timeframe reflects better the current situation and gives more accurate and useful information for current and future costing purposes.

Machine cost consist of electricity and maintenance. Large share of the total machine cost consists of electricity usage. It varies from 60% (for plastics) to 85% (for rubber) of total machines costs. The FJV has a single power meter from the electricity supplier, thus accurate power consumption information is only available on a company level. Measuring the individual machines' power consumptions would be possible, but this would give very uneven results, since the power consumption of a given machine varies significantly between manufacturing phases (warm-up, set-up, production etc.) and even between different products being manufactured. Thus, a direct measurement of machines one-by-one is not a reliable approach, and a more average standard cost had to be determined by different means. The initial plan was to measure the power consumption for different departments for example during a one-week measurement. This would give a good background for more in-detail power consumption analysis (4). Unfortunately, it was not possible to measure the actual power consumptions on department level due to limitations of the measuring device.

In accounting the power bill is divided to different production departments i.e. cost centers. The percentages which different production departments bear is fixed. It is determined by sum of nominal electrical powers of all machines in one department. This assumption stands only when the utilization rates of departments is close to equal. However, the average machine utilization rates for plastics department and rubber department were 34% and 21%, respectively. In this case, the rubber department would bear a larger share of electricity cost that it has really caused. To compensate this, the dividers were adjusted with the utilization rates of departments to have reliable and fair power cost distribution.

After the costs were as correct as possible on cost center level, the costs could be broke down to machines. As the electricity consumption of a single machine was impossible to obtain accurately and exact maintenance resource consumption was not available, the total numbers had to be divided by other means. Dividing the resource consumption equally would definitely not be a good option, as larger machines consume significantly more resources. Thus, the larger machines should have a larger share of the costs and respectively the smaller machines should have a smaller share of the costs. To determine the size of a machine in a comparable and numeric way, the maximum tool size of a machine was selected as size measure. The maximum tool size of a machine is the surface area of the tool plate. This measure reflects the size of the machine very well, and is available for all machines. Other possible measures would have been the manufacturer specified peak electric power or the clamping force of the machine, but these were not available for all machines in a comparable way. Another factor affecting the cost division is that for how long time the machine has been consuming the resources. No matter how big and power consuming a machine is, if it has been operating for a very short time compared to other machines, it would not have consumed a large amount of resources. Thus, the factor for a machine *i* is operating hours multiplied by tool area:

$$factor_i = operating\ hours_i \times tool\ area_i. \quad (3)$$

Some of the more expensive spare parts and large overhauls have been accounted in a way that the cost can be assigned to the machine in question directly. As these costs are on the same account than those that need to be divided by all machines, these machine specific costs must be first subtracted from the total, and after the total has been divided to machines, added to machines that they belong to. For a machine *i* the total operating cost for a given time can be obtained by the following equation:

$$machine\ cost_i = \frac{factor_i}{\sum factor} \times (total\ machine\ costs - machine\ specific\ costs_i) + machine\ specific\ costs_i. \quad (4)$$

The machine hour rate that can be used in future standard costing is obtained by the following equation:

$$machine\ hour\ rate_i = machine\ cost_i \times operating\ hours_i. \quad (5)$$

4.8 Labor hour rate

Every blue-collar employee is obliged to check-in and check-out from every operation. Thus, his or her working hours will be allocated to the production run. As number of manufactured pieces (accepted and rejected separately) is reported after working shift, the time spent per pieces can be calculated very accurately. Unfortunately, this applies only to direct labor, but not at all for set-up activities. Also a small amount of time leaves unallocated. It is mainly not due to breaks, but due to unexpected changes in manufacturing and human errors. For example, if a personnel is trained for an operation, but the training information is missing from the system, the employee cannot check in for the operation. Also, if an additional employee is required for product finishing and the BOM is not prepared in a special way to allow additional operator, the second operator cannot check in. This can happen if when the mold wears and more finishing is required to meet the quality standards. Despite providing quite accurate data on a production batch level, implementing this data to standard costing system does not seem viable, as all other actual data is available only on department level.

To calculate the actual hour rate for standard costing, the actual paid wages and personnel related expenses were divided by actual fulfilled working hours. This gives the total labor hour rate. The calculating period was full year 2015 to ensure that all additional personnel related payments such as taxes and holiday payments are included, as some payments are not accrued within a year. As wages vary slightly between departments, the hour rates were calculated separately for different departments.

4.9 Bill of Material

Bill of material is one of the most important documents to implement standard costing. All work phases should be present on the BOM, and the more significant work phases should have correct costs. The BOM also contain information irrelevant for costing purposes.

At the FJV the material usage and main manufacturing stage cycle times were recorded quite accurately, since they were controlled regularly. The controller recorded the actual cycle time, net weight of the product and the gross weight that included burrs. Thus, the gross weight represents the actual material usage. On the other hand, machine set-up times were only very rough estimates and they were not controlled regularly. This is most likely due to that their direct cost effect was unknown or less significant compared to material consumption, or due to the less significant effect to yield in a longer production run.

At the FJV the Bill of Material serves two purposes: material planning and working instructions. The material planning part is to ensure that enough material is available in the warehouse. It is closely tied to other functions of the ERP system. The working instruction part for manufacturing is to define the required tools and production steps. It also enables the quality controllers to acknowledge that the quality control has been carried out. However, since the Bill of Material was not used for standard costing, the BOM was not constructed in a way that it would serve standard costing as it is. One significant shortcoming in plastics manufacturing was that drying of material and tool installation was on same machine group (i.e. cost group). The problem was that material drying loads only the drying machine, since it does not require an operator, but the tool installation loads a person. From a costing point of view these two operations look the same in ERP, although in real life they cause completely different costs. To correct the problem, a machine group for drying machines was established. Now the drying time, for example four hours, only causes cost of the drying machine, which is in the range of 0.60 EUR/hour, based on the electricity usage of an average dryer. The tool installation (and tool removal and machine set-up) remains on the cost group that contains the human resource.

4.10 Invoicing of outsourced secondary operations

For a long time, operations that were not profitable to do in-house, have been outsourced to number of subcontractors. These operations have been mainly manual deburring, repackaging and other finishing tasks. Also, manufacturing of whole parts that were not profitable to do in-house could be subcontracted. The parts requiring finishing were sent to subcontractors and the subcontractors returned the finished good. Only the actual work was invoiced and the parts stayed in the property of the FJV. Starting from July 1st 2016, the process was changed so that first the semi-finished goods were sold to a subcontractor. The goods were invoiced at around 90% of the sales price of the finished product. After the subcontractor has completed the finishing, the goods were purchased back by the FJV

with the same price added with the agreed finishing cost. This invoicing process has some advantages: first, it is the subcontractor's responsibility to keep track of exact amounts of unfinished, finished and scrapped goods. The new process has already shown less loss compared to the earlier process. Second, the process ensures the proper handling of waste material, since it is billed back and returned to the FJV for proper waste handling.

This process, however, has some significant disadvantages for standard product costing and financial management reporting. First, the major drawback is that standard product costing starts from purchasing the material and end to the point where the product is sold. Thus, selling the product to a subcontractor and purchasing it back means that we don't have any more a product that's lifecycle starts from raw material and ends to sales to the end customer. Instead, we have a product that is manufactured from raw material that has proper labor and material information and is sold to a subcontractor. In addition, we have a finished product that is sold to the end customer, but it only has material cost and sales margin. This two information has to be combined in order to get the proper cost structure of the finished product that will be sold to the end customer. To do this, the final product's BOM has to include the semi-finished product and a material row that states the cost of outsourced finishing. In this case, the final product need to be treated as self-manufactured instead of purchased, despite that in the real life it is purchased from the subcontractor. Another problem is, that sales to the subcontractor are posted on domestic sales account and purchases from the subcontractor are posted on the domestic raw material purchasing account. This has the following consequences: The officially reported external revenue of the FJV increases, all KPI's that are measured in percent of revenue will decrease (e.g. Sales Margin %, EBIT % etc.) and the material usage percent of production units will increase. This makes comparing financial numbers and KPI's before and after 1st of July 2016 difficult. In the present situation, my recommendation based on these facts is that the sales to the subcontractor would be posted on a separated account (separated from the standard sales account). Respectively, the purchases from the subcontractor would be posted on a separated account (separated from the standard purchases account). This would allow the calculation of management account metrics on real numbers without the artificial sales. Of course, since the semi-finished products are actually sold to the subcontractor, the sales must be included in the statutory financial reporting. It must be noted that the invoicing process of subcontracted finishing was changed independent of this study and only based on the decision by the FJV's management.

4.11 Batch sizes

One key number in calculating the cost of mass manufactured products is the batch size. If the batch size is not set correctly, it would result to overcosting or undercosting. This occurs for example if set-up costs are not assigned to a manufacturing batch. It highly affects the profitability, as set up costs are divided for the manufacturing batch. Currently the ERP had a data field only for Minimum Order Quantity (MOQ), which is essentially

a minimum batch size for manufacturing. During this study it was found out, that most of the time batch sizes are significantly larger than the MOQ. Using the MOQ as a standard batch size for standard costing would lead to overcosting those products that are manufactured in larger batches than the MOQ would indicate, since per-item would be allocated more set-up costs than in the case of a larger batch size.

Since the information of standard batch sizes were missing, the best available estimate was the average batch size for each item. Using the average batch size as a standard should reflect the real situation quite well. Another option would have been to ask the department managers for estimates, but it would have been rather time-consuming since the information was not readily available. To create the data set, a timespan from 2015 January 1st to 2016 September 30th was chosen. It was important to include year 2015, because a lot of products assembled or finalized today include parts that were manufactured earlier. Thus, although some parts are not manufactured anymore, their manufacturing cost is still relevant as they are still sold in a form or another. The batch sizes of most significant products were confirmed with manufacturing organization.

In future, the batch size for new products should be set commonly by sales organization and production organization. The batch size affects the cost level, and it is important that the sales organization offer products on realistic price that the manufacturing organization is capable of fulfilling. Manufacturing organization must commit in manufacturing batches that are no smaller than the commonly agreed batch size. Manufacturing a smaller batch should be approved by the Production Manager.

5. RESULTS AND ANALYSIS

5.1 Changes in posting principles and BOM practices

In the end, the posting principles required only minor refinements. More notably some fixed/variable classifications were changed and utilities such as electricity and gas were changed to be posted as other variable instead of raw material. The posting of utilities as raw materials originates from a Hungarian practice, as it would be unfavorable in taxation to post those costs elsewhere. The actual account number was not changed, but grouping of accounts was changed so that internally the account belongs other variable costs.

As the ERP has earlier not been utilized to support any kind of costing, some principles needed to be put in practice. For example, the number of operators need to be stored on the BOM in a structured way, instead of only the written comment which was the earlier practice. A more comprehensive list of changes in BOM practices can be seen in Appendix B. The following changes were the most significant and interesting.

First, store the total number of machine operators in a structured, numeric way instead of a written comment in a free text field. As it has not been utilized for any calculation, it has been more convenient to just write a comment on the BOM. To allocate labor costs, the number of operators need to be defined explicitly and kept up to date. In the end, the new practice does not cause too much trouble for the responsible persons, as most items are produced with one operator, which is also the standard setting for a new BOM.

Second, specify minimum required elements of a BOM. As production is serial production and the production is standardized, the BOM's of different products within a product category are very similar. To ensure that these products are costed with the same principles, the BOM's must be constructed using documented principles. Some items on the BOM are always mandatory, whereas other are added only if applicable. Examples of the mandatory items are the raw material(s), machine set-up, the actual main manufacturing phase and warehousing. The full list of mandatory items also includes multiple quality and set-up related steps. Examples of the optional items are finishing, packaging and packaging material, and also some more specific steps. Especially the machine set-up is very important for every item, as it accumulates batch-related costs. Despite its importance, it was not too uncommon to be left out, resulting significant distortion of unit costs.

Third, define a connection between a semi-finished and a finished product. As the semi-finished product is essentially the raw material of the finished product, it must be explicitly defined on the BOM to include its costs in the costs of the finished product. It has always been visible by the item number which semi-finished product is processed further

to a finished product, but for costing purposes it need to be defined in a way that costs can be accumulated all the way from raw material to finished product, which is finally sold to a customer.

And finally, define responsibilities for agreeing on batch sizes and obeying the agreed batch sizes. Personnel from sales organization and manufacturing organization should agree on a batch size in a way that sales can calculate with a good enough profit margin and the manufacturing can commit to manufacture with that agreed level. It could be that sales would calculate with a larger batch size to show smaller unit costs and thus be able to offer with a lower price, whereas the batch size would be impractically large for manufacturing planning. Manufacturing a smaller batch than planned would result higher unit costs, as batch-level costs are divided to smaller number of units. To avoid a such situation, the batch size (and also production rate i.e. units per hour) should be commonly agreed.

5.2 Machine hour rate calculation

After identifying correctly the costs that are regarded as machine-related costs, it was possible to calculate new machine hour rates and compare them to original machine hour rates. The machine hour rates were also compared to Teknikum's machine hour rates, although as no identical machines were available, the result of the comparison was only that the costs are on the same magnitude.

Generally, hour rates of plastics machines were decreased in most cases compared to old rates, whereas hour rates of rubber machines were increased with exception of three machines (in Figure 2 two identical machines had a -28% decrease, thus the markers overlap). However, the changes were not uniform at all, as for plastics machines the highest increase was 61% and the highest decrease was -70%. For rubber machines the changes were 178% and -28% respectively. Of course, such large changes should be questioned, but as no explanation of the old machine hour rates could be given it is justified to use the new numbers, as they are calculated on a documented basis. These rather large and non-uniform changes confirm that the old machine hour rates were not based on a similar system. What is interesting, based on Figure 2 and Figure 3 seems that the hour rates of small machines were earlier too high and the hour rates of large machines were earlier too low. The new hour rates bring more contrast between large and small machines.

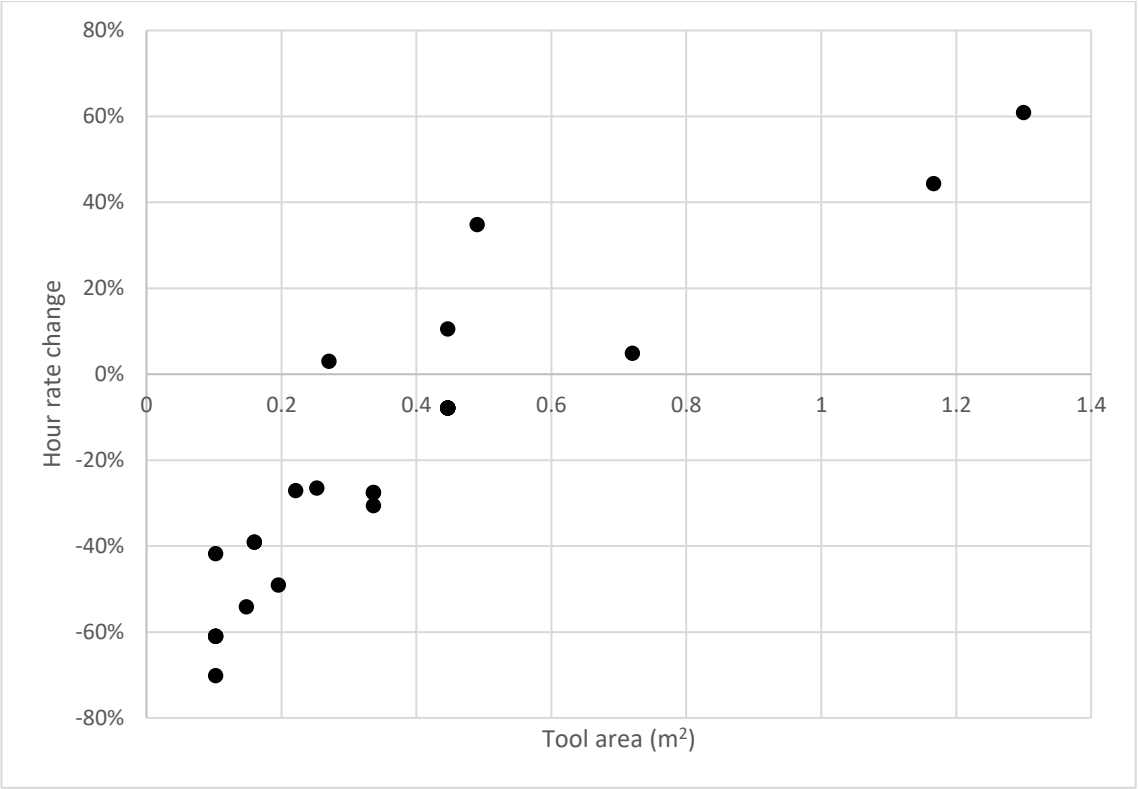

Figure 2: Changes in machine hour rates of plastics machines

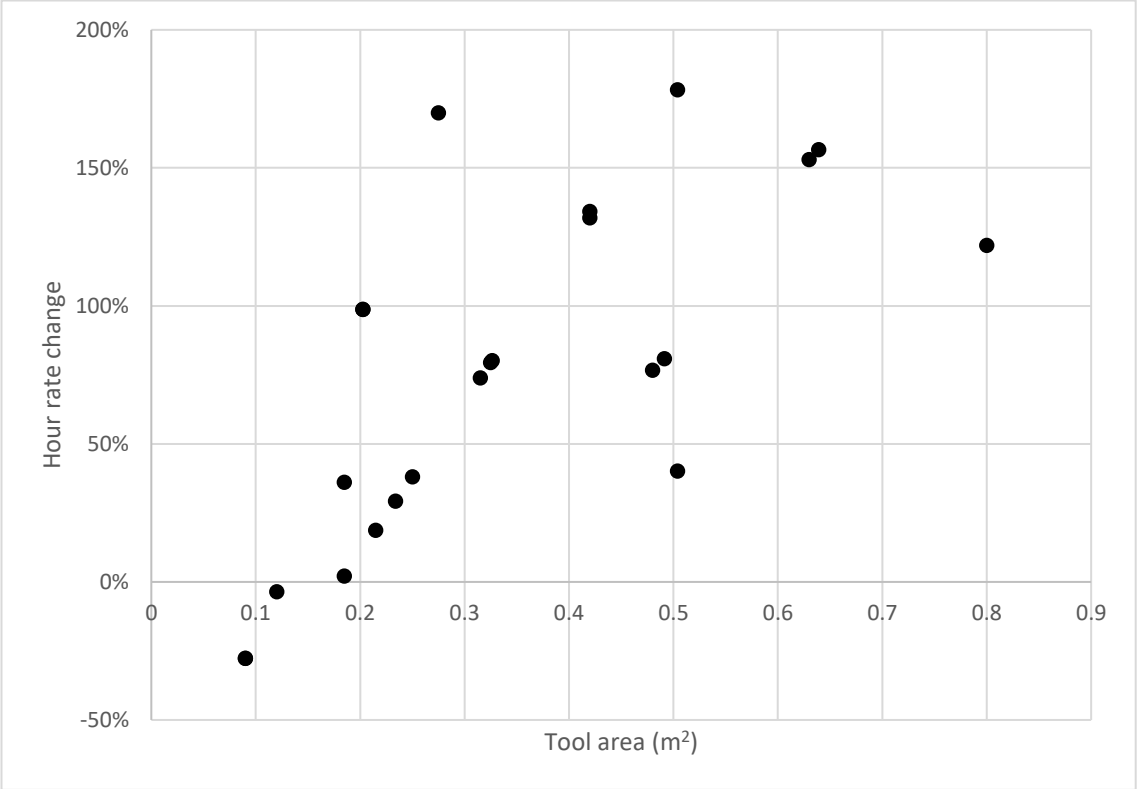

Figure 3: Changes in machine hour rates of rubber machines

To verify that the calculated machine hour rates are correct, a standard cost calculation was made for period from 1/2016 to 9/2016 i.e. the first three quarters of 2016. The results of this costing are described in the next chapter.

5.3 First results of standard costing

After ensuring the correct posting of costs, calculating proper machine hour rates and ensuring that the BOM's for products are mostly correct, the initial standard variances could be calculated for variance analysis. At this point it was not totally clear whether or not all calculations were correct, and thus if the variances were reliable. The calculated variances for plastics and rubber departments are shown in Table 2.

Table 2: Initial STD-variances for plastics and rubber departments

	Plastics	Rubber	Plastics & Rubber
Material STD-variance	1.0%	-7.3%	-0.4%
Labor STD-variance	-11.3%	-10.2%	-11.0%
Other variable STD-variance	147.6%	4.5%	75.2%

In this table, a positive variance indicates that the actual performance has been better than what it should have been according to standard cost. This is because data is presented in Qlik Sense in a form of income statement, where costs are negative, as opposed to Drury's (2012) presentation where costs are positive numbers.

At the implementation stage of standard costing system, we can see from these variances that how accurately the machine costs, labor costs and BOM's have been set. Material variance is very small for plastic and also reasonable for rubber. The negative material standard variance for rubber indicates that the actual material consumption or price has been higher than what was set by standard. This is a bit surprising, as lots of effort have been used to assess the material consumption. Some possible reasons for the error are missing materials from BOM's or bias caused by currency conversion, as for simplicity a fixed EUR/HUF conversion rate of 300 was used, although the actual rate fluctuated between 303 and 318 in 2016. It however causes a bias only when raw material is bought in one currency and the finished product is sold in another currency, which was not a too common case. The labor standard variances of plastics and rubber is moderate, but they are very close to each other, with only a 1.1 percentage point difference. This indicates that problems causing the variance could be very similar. One known reason for the variance is that the wages of material handlers and quality inspectors are accounted to variable costs of the department, but these costs are not accumulated on BOM's, because they are fixed regardless of number of units produced or number of batches produced. In other words, these costs are actually fixed costs, but at the moment due to reporting needs it is

not possible to account these costs to department fixed salaries. The other variable part is essentially the machine cost. It is evident, that these numbers contain significant errors, as plastic's variance is so high. Although the standard variance of rubber is very reasonable, it is important to understand the numbers deeper. As discussed in chapter 4.6, many costs are divided between cost centers by a fixed divider, although the actual costs may fluctuate and differ from the fixed percentage. For this reason, the "actual" numbers against that standard variances are calculated may not be absolutely correct. This applies only to other variable costs, as direct material and direct labor are accounted only to one cost center without utilizing dividers. The error caused by incorrect division can be reduced by analyzing the cost centers together. This way it is meaningless how the costs are divided between the cost centers. However, it does not completely eliminate the problem, as main machine costs such as electricity is still divided to foam cost center and to supporting functions. Thus, to further eliminate the error, the foam cost center should be grouped together with plastics and rubber. Unfortunately, this is not possible, as no standard costs are available for foam products. By analyzing the plastics and rubber cost centers together, the other variable standard variance is still very high. As direct labor cost and machine cost are accumulated together in most cases on BOM and the labor cost seems to be on the right magnitude, it is safe to assume that the BOM's and the cycle times are mostly correct. This assumption can be made, as the actual labor cost is correct. Thus, it seems that the machine cost calculated in chapter 5.2 are not correct. At this point of study after re-evaluating the machine cost calculation formulas, it seems that one source of error is that the calculated machine hour rates include the internal maintenance, but as internal invoicing is not carried out, the cost of internal maintenance does not appear on accounts of plastics or rubber cost center. In other words, the machine hour rate accumulates costs that the actual accounts do not contain.

5.4 Further recommendations

In this chapter are described topics that could not be completed during the study. There were multiple reasons why these actions were not executed during the study, including, but not limited to e.g. lack of resources in the company and perceived small benefit compared to required effort.

First, implement new cost centers according to Appendix A. This is an important step to allow accurate allocation of fixed overheads. It is not the most urgent action for variable costing, but making the cost center changes early allows utilizing the information later.

Second, implement internal invoicing of tooling. As tooling services are provided both internally and for customers', it is not entirely a supporting function. The cost of internal tooling is already compensated, but in a way that distorts costing, as discussed more in detail in chapter 4.6. To compensate the work without distorting costing the work should be invoiced internally.

Third, implement internal invoicing of maintenance. The issue is similar to the tool shop's issue, with the exception that maintenance does not generate any external revenue. Still the costs need to be invoiced internally.

Fourth, set up separate accounts for sales to subcontractors and purchases from subcontractors. As described more in detail in chapter 4.10, the sales to subcontractor are presented on the same domestic sales account as actual external sales are, and respectively purchases from subcontractors are presented on the same domestic purchases account as all other purchases are. To be able to measure the actual external sales and to calculate correct KPI's, separate sales and purchase accounts should be set up.

Fifth, improve database structure so that exporting scrap rates for long timeframe is possible. This is purely an information technical issue, as the current database structure results an impractically slow query of scrap rates. Thus, at the moment it is not possible to get long (at least one year) averages on product-level for all manufactured products at once in a reasonable time. At the moment about 4 months of data could be queried for only one department within 8 hours.

Finally, automate the data export process from the FJV's ERP to Teknikum's Qlik Sense. Also this is an information technical issue requiring 1) automatic initialization of queries in ERP at a given time e.g. every day at 01:00, 2) transfer exported raw data between the FJV's and Teknikum's servers and 3) import data to Qlik Sense.

6. DISCUSSION AND CONCLUSION

6.1 Discussion

To start with the needs of costing, the costing needs that drive this study and are the motivations for Teknikum are in line with the costing motivations found in literature. This is definitely a sign that the grounds for this study are well justified. For the costing methods, no directly fitting methods seemed to be presented in literature. Thus, the ABC standard costing framework was created and implemented in this study. The framework combines the best practices of activity-based costing and standard costing. Due to Teknikum's current costing system implementation, the standard costing part was decided to be implemented in a way that amount and price components of variances are combined to a single variance measured in monetary metrics i.e. in EUR. Direct labor, material and other variable costs were still measured separately, making it three different components. The decision to combine the amount and price variances contrary to opinions in literature was a decision that could be criticized, but with the available resources and skills the larger leap could have failed.

An important question is how valid the results of costing are. As the calculated machine costs were evaluated in chapter 5.3, it seemed that the machine costs were set too high, resulting the better actual performance than what was expected by the standards. Thus it seems that part of the results, the machine costs, are incorrect. But another important question is, what is actually considered as valid cost information? For costing in general, the most accurate cost information would be the ultimate goal. That is especially when cost information is used to do make or buy decisions, or continuation/discontinuation decisions. In those cases the absolute accuracy is the most important factor: for make or buy decisions the cost of the "buy" option is usually known precisely, as it is the price on market or based on a supplier's offer (although prices can vary in future), and for continuation/discontinuation the sales price of the product is exactly know (again, prices can vary in future). In these cases the most accurate costs give the best result, as these aspects to compare can be regarded accurate. But for this specific case, where one of the objectives for costing is to make decisions of where to produce a specific product, the costs are compared to another production location's costs. In this case, another important factor is that the costing principles between the two locations i.e. factories are as closely identical as possible to ensure that costs are comparable. For a transfer question it is actually not relevant whether a product is profitable or not. For example, an unprofitable product might need to be kept in the product mix to sustain a certain customer relationship, where discontinuation of a product would end the relationship. In a such case, the important question is, in which factory the product could be manufactured with minimal loss of profit. To answer that question, the costs of both factories need to be comparable i.e.

calculated with same principles. In a such example case, naturally an important question is also whether or not to sustain the whole relationship with the customer. Answering that question would require correct costs on absolute level for all the products that the customer is buying. For customer profitability, also the costs to sustain the relationship should be considered (Kaplan & Cooper 1998, pp. 89–91). This is not to understate the importance of absolute correctness of cost information, but rather to highlight the importance of correct and documented costing methods.

As one goal of the study was to make costing more accurate i.e. decrease amount of error in costing, it should be discussed what kind of errors the performed actions decreased. Of the three kinds of errors, this costing system affected most the specification error and aggregation error. This is mainly because of the new cost center hierarchy, as it was designed to allow cost allocation respecting the cause-effect-relationship and the cost centers were chosen so that they form homogenous cost pools. As the new cost centers could not be implemented during this study, the actual performance of the design choices cannot be evaluated. As this study was focused on the cost system development, more detailed and technical details were omitted. Thus, measurement errors were not the key focus of this study. Certainly some room for improvements in measurement were left in more complex operations, such as machine set-ups. This is because in reality machines usually consume more electricity during warm-up compared to production, some scrap material may be generated, and multiple different personnel may be needed for the set-up process. And unfortunately, giving a standard time for a set-up is very difficult, as it depends on the machine & mold combination, and also variation exists due to e.g. condition of machine and mold.

As it was expected, the actual process was a lot more complicated than the literature suggested. The studied literature mainly ignores the practical challenges and decision-points of building a costing system. However, this was expected, as literature gives just the theoretical framework.

6.2 Reflections on the study

Despite a fully working automated costing system could not be implemented within the timespan of this study, some significant actions have been taken in the organization towards Activity Based Costing and general good practices of standard costing. As seen afterwards, the project was quite broad with aspects of cost system study, cost system design, IT integration, changing operational practices and probably most important influencing attitudes. As knowledge of standard costing and variance analysis at the FJV was nonexistent and also knowledge of Activity Based Costing was generally on a poor level (with some exceptions). This significantly affected the attitudes towards the new costing system. This was by no means resistance, but rather a lack of genuine enthusiasm, as the organization could not see the benefits of improved costing system. This was an issue that

should have been addressed with a larger emphasis. Getting the key personnel in the organization convinced about the benefits of new costing system would have most likely helped to create a more excited atmosphere, thus helping everyone to seek for the best practices.

Making changes in the operations and practices of an organization are not an easy task. It is not enough to just tell how thighs should be done, rather help and support should be provided. Also the results of the changes should be monitored, and action should be taken according to how well the organization has adapted to the changes. Without continuous control, it is easy to return to old habits, especially if the organization itself does not see direct benefit from the changed practices. Regarding this study, the most important part that require control and monitoring are the changes in BOM practices. Rigorous following of all the details is important for accuracy of costing, but without control it is easy to cut corners, as the importance may not be obvious for every individual. For this part, more time and more effort would have been needed to ensure that the whole organization is committed to the changes. An impression was left that without someone actively taking responsibility for sustaining and further developing the costing process on-site in Hungary, the process may not self-sustain.

6.3 Further research topics

An interesting matter emerged during discussion with the quality department: the costs of sample production and trial runs are unknown. The sample production requires significant support from the quality engineers and process engineers, and in some cases even from the quality manager. Also the set-up costs are significant per item, as batch sizes are small. In the first trials, all items could be manufactured just for testing purposes, so from costing point of view the scrap rate would be 100%. To evaluate the profitability of a product for its whole lifecycle it is important to include also these costs that are not unit-level or batch-level costs, rather product-category level costs. At the moment sample production and trial runs cannot be distinguished from regular manufacturing batches. A further research topic would be to study the manufacturing and non-manufacturing costs of sample production and trial runs. Further, these manufacturing costs should be distinguished from serial manufacturing in ERP so that serial manufacturing performance could be evaluated separately. This would allow managers to evaluate the actual performance of manufacturing process, which accounts only for the serial manufacturing. The calculated sample production costs should be added as a new product-category-level cost.

Regarding the costing of whole Teknikum group, one future research topic could be to investigate the possibility of breaking down the labor, material and other variable variances further to include a price component and an amount component, as suggested in literature. As an example, for material these variances are caused by two very different reasons. For material price variance, the purchasing department is responsible for it;

whereas for material amount variance, the responsibility is at the manufacturing department. As currently the variances are combined to a single variance, investigating the root cause is difficult. It possible that there is simultaneously a favorable and unfavorable variance for the two components and they cancel out each other. This prevents managers from seeing the problems that cause the unfavorable variance, and thus taking corrective actions. But on the other hand, it also prevents managers from seeing what has been done correctly to achieve the savings, and thus keep those practices going.

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Appendix A: Cost pools

	Description	Note	Cost assignment method	Cost alloc. base
01 Plastics	Salaries and wages of employees in plastics department. Also quality personnel and logistics personnel dedicated to plastics department. Expenses related to these employees (travelling etc.). Raw material, outsourced services. Expenses of plastic machines			
02 Rubber	Salaries and wages of employees in rubber department. Also quality personnel and logistics personnel dedicated to rubber department. Expenses related to these employees (travelling etc.). 1K (i.e. purchased) Raw material, outsourced services. Expenses of rubber machines			
98 Foam	Salaries and wages of employees in foam department. Also quality personnel and logistics personnel dedicated to foam department. Expenses related to these employees (travelling etc.). Raw material, outsourced services. Expenses of foam machines			
06 Packaging	Cost of packaging material and supplies		Invoiced to customer	
07 Tooling	Salaries and wages of employees in plastics tool shop. Expenses related to these employees (travelling etc.). Raw material, outsourced services. Expenses of tooling machines	Tooling shall be invoiced to customer	Invoiced to customer or included in product price	
08 Maintenance	Salaries and wages of employees in maintenance. Expenses related to these employees (travelling etc.). Materials, outsourced services		Internal invoicing to machines/departments	
Mixing plant	Salaries and wages of employees in rubber plant. Expenses related to these employees (travelling etc.). Raw material used to manufacture 0K (i.e. in-house mixture) rubber, outsourced services	Product of mixing plant, 0K rubber, shall be debited internally to 02 rubber department	Internal invoicing to Rubber department	
Production general	Production related purchases that can't be allocated to another cost center directly. Costs of buildings upkeeping	Common supplies and services that are used by different departments	Allocated to production departments by revenue	Revenue
Purchasing	Salaries and wages of purchasers. Expenses related to these eympoyees (travelling etc.)		Allocated to production departments by number of raw material purchases	Number of purchases rows

	Internal logistics and warehousing	Wages of forklift operators, warehouse staff, loading/unloading trucs. Expenses related to these employees (travelling etc.). Costs of forklifts (maintenance, fuel, etc.), costs of warehousing.	Excluding material handling personnel that belong directly to departments	Allocated to production departments by average stock value	Average stock value
	External logistics	Truck driver wages. Expenses related to these employees (travelling etc.). Cost of trucks (maintenance, fuel, etc.)		Invoiced to customer or included in product price	
	Sales	Salaries of employees in sales department. Expenses related to these employees (travelling etc.), costs of sales activities. Comissions for external sales agents		Allocated to products by number of customer visits	E.g. number of customer visits
	Quality	Salaries and wages of employees in quality department. Expenses related to these employees (travelling etc.). Outsourced services	Excluding quality personnel that belong directly to departments	Allocated to production departments (variable) and to products (fixed)	E.g. by claims and new product ramp-ups
99	Administration	Salaries and wages of Management, HR, IT, Finance and Accounting. Expenses related to these employees (travelling etc.). Other administrative general costs that can't be allocated directly to other cost centers	Nothing production related!	Allocated to production departments by revenue	Revenue

Appendix B: BOM practices

Requirements for Bill of Material (Product Structure)

for correct variable cost calculation

The following general rules apply for all products

- Preparation time “Elők idő” should be used for batch level operations
- Cycle time “Ciklusidő” may only be used for operations that concerns a single product or no. of products manufactured in one cycle (ie. number of cavities)
- For new products the commonly (by sales and production) agreed batch size shall be inserted in “Standard mennyiség” field on “Kalkuláció/Értékelés” tab.
    - Smaller amount that the agreed batch size may not be produced unless approved by Production Manager

Molded plastic and rubber products

The following general rules apply

- The main manufacturing phase includes the following costs
    - Total variable running costs of the machine
    - Total labor costs of one operator
- If the operator does the finishing, “manual finishing” shall **not** be included separately on BOM
    - If another person is required for finishing “manual finishing” row shall be added with identical cycle time to indicate the total 2 operators
    - If the option of second operator is needed, the “manual finishing” row may be added **without set-up or cycle time information**
    - Also other operations (e.g. packaging) that fit in the operator’s time shall be without cycle time
- If the machine operates in automatic mode so that no dedicated person is at the machine, the removal of personnel shall be indicated in the following way:
    - In the properties of the manufacturing phase, in “Teknikum”-tab, set “Tartalék technikai érték” to 1

Each BOM that includes the main manufacturing phase[1] must contain the following data:

- Raw material(s)
- Preparation of raw material
- Daily tool inspection
- Required tool(s)
- Installation of tool
- Machine set-up
- Approval of first product
- Main manufacturing phase
- Quality inspection during manufacturing
- Approval of last product
- Removal of tool

- Warehousing

And if applicable

- Drying of raw material (for plastic)
- Manual finishing (additional operator)
- Machine finishing
- Packaging material
- Packaging
- Possible other operations

(1 Injection molding, vulcanizing, punching, stamping etc.

Rubber finished part with outsourced finishing

If the semi-finished part (F) is manufactured in-house and the finishing is outsourced, the BOM of the **finished product** must contain the following information

- The semi-finished part
- 51070 “Technikai cikk!” material row with amount 1 pcs = 1 HUF indicating how much the finishing costs per item

Outsourced assembly

If the assembly of a final product is outsourced AND at least one of required parts are self-manufactured, the BOM must contain the following information

- All parts that are required for the final assembly
- 51070 “Technikai cikk!” material row with amount 1 pcs = HUF indicating how much the assembly costs per item
- If it is required to specify raw materials of required parts (i.e. not materials of the final product) for material planning purposes, for these materials must be set on “Teknikum”-tab “Tartalék technikai bool” checked

If the final assembly contains no self-manufactured parts, the contents of BOM does not matter for costing.